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Assessment of osteoporosis level using Dual Energy X-ray Absorptiometry (DEXA) in the Kingdom of Saudi Arabia (KSA)

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ABSTRACT

Osteoporosis affects the skeleton (bones) due to decreasing bone mineral density (fragile bone) caused by altered bone microstructure. A retrospective study aimed to evaluate osteoporosis levels among middle-aged in the KSA to correlate bone mineral densitometry with patients' variables (age, gender) and risk factors vitamin D, Thyroid Stimulating Hormone) (TSH) level and body mass index (BMI), using Dual Energy X-ray Absorptiometry (DEXA). The study`s sample included 100 osteoporotic patients aged (40≤-61≤) who were diagnosed at King Abdullah Bin Abdulaziz University Hospital in Riyadh between February 2021 and December 2023. The data were analyzed by (SPSS) version 22. The results revealed that the average mean age was (67.24). The most common age groups affected by osteoporosis were (≥61) and (41-60), with a percentage of (77%) and (18%) respectively. Osteoporotic females were affected more than males, with a rate of (93%) and (7%y) respectively. Also, the high BMI or obesity patients were the most affected by osteoporosis, with percentages (of 35%) and (34%), respectively. A (92%) of osteoporotic patients were within an average of thyroid disorder. Comparing the femur's neck and lumber areas, the latter had a higher percentage of mild and severe osteoporotic areas. In addition, the results showed a significant correlation between the T score on the lumber area and the neck of the femur area. The study concluded that DEXA is the best and outstanding radiological modality to diagnose the level of osteoporosis for the lumber area and the neck of the femur.

Keywords: Osteoporosis, KSA, T-score, BMI, DEXA, BMD, vitamin D (V.D)

1. INTRODUCTION

Osteoporosis is a silent metabolic bone disease defined by a gradual decrease in bone mass and bone quality, causing bone fragility and an increased risk of fracture (Lim and Bolster, 2022; Wilson-Barnes et al., 2022). It occurs due to many bone-resorbing cells and a decrease in bone-forming cell activity. When new bone

formation cannot catch up with bone loss, bone eventually weakens, and becomes more prone to fractures (Rowe et al., 2024). Osteoporosis develops when bone resorption exceeds bone production during bone remodeling. The most frequent type of bone disease is decreased bone mineral density (BMD) (Rowe et al., 2024; Sözen et al., 2017). It is a complex disease resulting from environmental and hereditary variables. According to the literature, mutations in the vitamin D receptor (VDR) gene significantly impact mineral metabolism, resulting in decreased bone density (Sözen et al., 2017; Ansari et al., 2021).

Osteoporosis has a high prevalence, resulting in an osteoporotic fracture every three seconds. Osteoporosis brings about more than 8.9 million fractures worldwide annually, which are a significant cause of mortality and morbidity (Chin et al., 2020). A previous study indicates that altering several lifestyle choices may help reduce the prevalence of osteoporosis (Pouresmaeili et al., 2018). According to epidemiological studies, (30.7%) of males and 34% of healthy Saudi women between the ages of 50 and 79 have osteoporosis (Khired et al., 2021). In 1960, KSA life expectancy increased from (45–67) years to (75.7) years in 2013, and osteoporosis will become even more common. Lack of regular exercise, insufficient calcium intake, and a higher incidence of vitamin D deficiency are some of the primary lifestyle factors contributing to the high prevalence of this disease.

Because KSA is a region with a high prevalence of vitamin D insufficiency, bone health is becoming a significant worry in the kingdom, where femur fractures cost billions of dollars annually (Alghamdi et al., 2023). A DXA scan is an exact type of medical imaging test and the most common machine used to assess bone density and osteoporosis. It is called dual-energy X-ray absorptiometry, DEXA, or DXA. It is the most common method for diagnosing osteoporosis and determining a person's risk of developing osteoporotic fractures. It uses a low dosage of ionizing radiation to obtain images of the inside of the body, usually the lower (or lumbar) spine and hips, to measure bone loss.

DXA is simple, quick, noninvasive, inexpensive, and painless. The exam requires little to no special preparation. DXA machines are often designated as either central or peripheral. Most DXA devices are central devices that assess bone density in the spine and hip. They frequently appear in hospitals and medical offices. The central equipment has a wide, flat table and an "arm" suspended overhead. Peripheral devices that evaluate bone density in the wrist, heel, or finger are often available in mobile health vans in the community. Ones are smaller than the central DXA devices, weighing only about 60 pounds. They might be portable, box-shaped, and offer a place for the foot or forearm to be positioned for imaging.

Other portable technologies, such as designed ultrasound equipment, are occasionally employed for screening (Krugh and Langaker, 2024; Link and Kazakia, 2020; Alwahhabi, 2015). However, central DXA is the standard technique that utilizes a T-score defined by the number of units called standard deviations and describes whether bone density is above or below average. When the T-score is recoded from (-2.5 to -2.9), it is deemed mild; when it is recoded from (-3 to -4) it is considered severe (Khangura and Mahood, 2022).

2. MATERIALS AND METHODS

This study was a descriptive retrospective cross-sectional study performed on a simple random sample of 100 patients with an age range from (≤40) – (≥61) years male and female who were referred to an orthopedic clinic and diagnosed with osteoporosis at King Abdullah Bin Abdulaziz University Hospital - Riyadh, KSA. Patients without osteoporosis were excluded from this study. The study was conducted from February 2021 to December 2023, and patients were willing to undergo dual-energy X-ray absorptiometry, GE Lunar IDXA (DXA), to determine bone mineral density (BMD). Data were complemented with information retrieved from hospital charts and electronic files in the radiology department regarding factors predisposing to osteoporosis: Medical history, gender, age, vitamin D, TSH level, and BMI.

SPSS version 22 was used to analyze the data, and tables and figures were then gathered to display the results. According to hospital protocols, an official letter from the college was delivered to the hospital, and data was collected once the department head had submitted the letter and given consent (IRB). All patients underwent a DXA scan, and the T score for the lumbar spine and the neck of the femur (hip joint) was measured. The World Health Organization (WHO) categories were employed as follows: standard (T score > -1.0), osteopenia (T score (-1.0 to -2.5), mild osteoporosis (T score < -2.5), and severe osteoporosis (T score -3 to -4).

Imaging protocol

Every patient underwent a central DEXA scan to assess bone density in the hip and spine area. After preparation, the patient comfortably lies on the table and is informed to avoid the chance of a blurry image by holding breathing for a few seconds before beginning the necessary x-ray exposure. An X-ray generator is positioned beneath the patient, with a scanning device above. When examining the spine, the patient's legs were supported on a padded box to flatten the pelvic and lower back lumber spine. When assessing the hip, the patient's foot was placed in a brace that rotated the hip inward. The detector in both positions was gradually passed over the region, displaying the images on the computer's screen to reconstruct the image with a clear T-Score.

3. RESULTS AND DISCUSSION

This descriptive cross-sectional retrospective study was applied to 100 participants in King Abdullah Bin Abdulaziz University Hospital in KSA-Riyadh using a DEXA scan to determine poor bone density (osteoporosis). The DEXA T-Score was utilized to measure bone density based on the osteoporosis levels (-2.5 to -2.9) and (-3 to -4) as markers. Based on demographic information (age, gender), the familiar site of osteoporosis, and risk variables (vitamin D, BMI, and TSH) levels, the study's analysis correlated the lumber spine region's T score of the femur neck.

The study showed that the patients' average age was (67.24) and that they were divided into three groups, as indicated in Table One: ≤40, (41-60), and (≥61). The most common groups of patients who had osteoporosis were elderly patients in two groups, Middle Ages (41-60) years and ages (≥-60) years, with percentages of (18%) and (77%) respectively, compared with young ages ≤40 years with percentages (5%) that match with a study Sözen et al., (2017), that reported menopause and aging is the most common chronic metabolic bone disease, which characterized by increased bone fragility in older people.

Table 1 shows the age years distribution

Age (years)	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 40 years old	5	5.0	5.0	5.0
(41-60) years old	18	18.0	18.0	18.0
More than 61 years old	77	77.0	77.0	77.0
Total	100	100.0	100.0	100.0
Average mean = 67.24 stdv.13.36				

The study showed the distribution of gender as appeared in (Figure 1). The females were the most affected gender with osteoporosis, with a percentage of (93%) and the male percentage was (7%) this matched with the study Adler, (2024), that stated, osteoporosis in men remains underdiagnosed and undertreated. In general, males fracture around 10 years later than women, with significant increases in fracture risk after roughly age 75, but disagreed with the study De-Martinis and Allegra, (2021), Which highlighted those men are under-screened for osteoporosis and exhibit secondary osteoporosis more frequently than women. This could be due to a variety of factors, such as a lack of interest in screening men for osteoporosis or a different sample size or population sample because the study was focused on the male population, who did not perform bone screening regularly.

Table 2 in this study demonstrated the frequency and severity of osteoporosis levels in the lumber area according to the T-score, of which the average mean was 3.15. According to the T-score (-2.5-to-2.9), there was a (48%) of patients affected with mild osteoporosis, while the T score (-3-to -4) represented a (52%) of patients affected with severe osteoporosis, matches the study Sözen et al., (2017), that reported according to WHO organization, a T-score of (−2.5) is a lower indicator that certified the osteoporosis and the greater the negative number, the more severe the osteoporosis.

Table 3 displayed the frequency of severity osteoporosis levels in the neck of the femur area based on T-score, with an average mean of (2.03). A (71%) of patients who suffered from osteopenia were considered borderline osteoporosis if not treated with a T score between (-1-to-2.4), While patients suffered from mild osteoporosis percentage was (17%), and the patients who had severe osteoporosis a percentage were (12%). That means the neck of the femur region had less effect on osteoporosis.

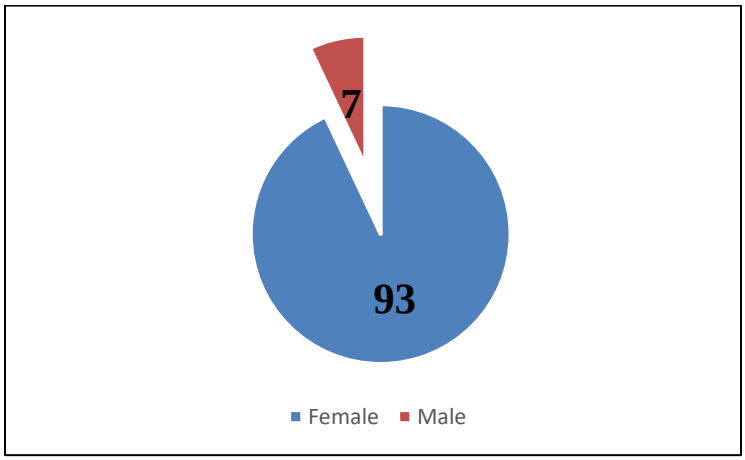

Figure 1 shows age\years distribution.

Table 2 T-score range of osteoporosis level in the lumber region

T score for lumber region	Frequency	Percent	Valid Percent	Cumulative Percent
(-2.50- -2.90)	48	48.0	48.0	48.0
(-3.00- -4.00)	52	52.0	52.0	52.0
Total	100	100.0	100.0	100.0
Average mean = 3.15 stdv.0.77				

However, a low T score of (≤-2.5) in the lumber spine area indicated that the same patient had an osteoporotic case; however, osteopenia in the femur neck has to be treated with osteoporotic therapy to prevent the femur neck from becoming impacted, as it is regarded as borderline osteoporosis or resulting in fracture if ignored. This agreed with the study Osipov et al., (2018) that reported the risk of fractures increasing the low bone density and deterioration of bone architecture. Also agreed with study of Abdelaziz et al., (2020) who reported the sensitivity, specificity and accuracy of DXA T-score in diagnosing osteoporosis and osteopenia cases.

Table 3 T score range of osteoporosis level in the neck of femur

T score	Frequency	Percent	Valid Percent	Cumulative Percent
(-1.00- -2.40)	71	71.0	71.0	71.0
(-2.50- -2.90)	17	17.0	17.0	17.0
(-3.00- -4.00)	12	12.0	12.0	12.0
Total	100	100.0	100.0	100.0
Average mean =2.03 stdv.0.83				

In addition, they were related to Tables 2 and 3, and based on the T score of the DEXA examination. Table 2 showed all the patients were affected with different levels of osteoporosis in the lumber area. In contrast, Table 3 showed some of the patients with osteopenia and others affected with varying levels of osteoporosis in the neck of the femur, so the lumber area was considered the first and more common site demonstrated with different levels of osteoporosis than the femur neck may be that due to the lumber area is carry almost the body weight. Chou et al., (2022), said vertebral compression fractures are the most common osteoporotic fractures, with an estimated 700,000 per year in the United States.

Figure 2 demonstrates the frequency distribution of V.D as follows: A (18%) of osteoporotic patients had a reasonable level of V.D or mild deficiency (insufficient) because there were fallen between (30-50) ng/ml, while (36%) of osteoporotic patients their V.D was optimum or near to optimum (borderline) because were fallen between (50-70) ng/ml but (24%) and (22%) represented an excessive V.D

level may be that related to some diseases like (heart, cancer) not mentioned on this samples that agreed with the study De-Martinis and Allegra, (2021), which reported in adults, VD deficiency can cause or exacerbate osteoporosis and induce osteomalacia.

The study of Ahwati et al., (2018) reported the serum vitamin D level references range that describes the classification levels of vitamin D and its relation with osteoporosis (Between 30-50 nmol/L-Deficiency some, but not all, persons in this range are at risk of deficiency relative to bone health outcomes-), (Between 50-75 nmol/L), Some refer to this range as insufficiency; others contend this range is sufficiency and (>75 nmol/L- Sufficiency). Also, the study of Lips and Van-Schoor, (2011), reported the fractures.

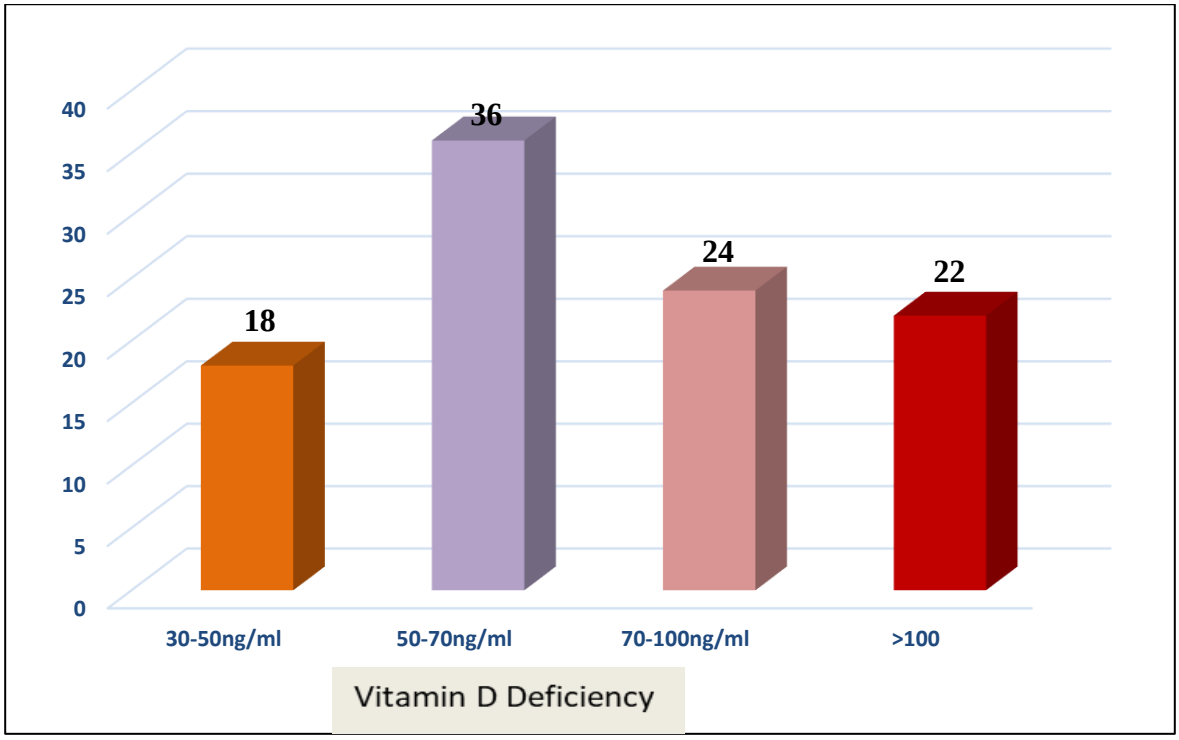

Figure 2 Vitamin D deficiency distribution.

Table 4 demonstrated a relationship between the TSH levels and osteoporosis, with an average mean (of 2.49) and (1.77). The higher percentage was (92%) for patients who were average from their thyroid disorder or controllable in medication, but (8%) of them had high TSH levels, which indicates an underactive thyroid (Hypothyroidism) that matched with two studies. The first one Delitala et al., (2020) demonstrated an increase in a high bone turnover osteoporosis probability resulting from untreated severe hyperthyroidism, which influences the degree of bone mass. The second study Williams and Bassett, (2018) stated that when the thyroid gland performance is not affected correctly, it can trigger a chain reaction that eventually impairs bone tissue function.

Table 4 Shows the TSH range distribution

TSH ranges\ mul\l	Frequency	Percent	Valid Percent	Cumulative Percent
(0.5-5) mul\l	92	92.0	92.0	92.0
(5-10) mul\l	8	8.0	8.0	8.0
Total	100	100.0	100.0	100.0
				Average mean = 2.49 stdv.1.77

A strong relationship between osteoporosis and body mass index (BMI) with average mean (27.73) and standard deviation (±5.58) was demonstrated clearly in (Table 5). The BMI was classified into five groups: <18 kg/m2 as low mass index (underweight) with percentage (4%), (18-24.9) kg/m2 as a healthy person with a percentage (27%), (25-29.9) kg/m2 as an overweight person with a percentage (34%), (30-34.9) kg/m2 as obese with a percentage (26%) and ≥35 kg/m2 as over obese with percentage (9%). All that means

the obesity decision according to BMI classifications has a strong influence on the deterioration of bone density turnover (osteoporosis), which is touched from increasing the percentages with increasing the BMI (weight) especially if groups (4) and (5) of BMI classifications combined as one group as ≥30 kg/m2 in the table (5) that represented the more Significant percentage (35%) based on some classification.

Whereas considered overweight represented a percentage (34%) that agreed with the study Chiu et al., (2024), that reported a BMI has a relationship between the prevalence and the incidence of osteoporosis. Underweight is an independent risk factor for osteoporosis. She was also agreed with the study Manar et al., (2023), which showed that body mass index (BMI) had a strong association with bone mineral density. Another study Lee et al., (2020), found that a BMI of (23.0 to 24.9) kg/m2 was the best range for preventing osteoporosis. Additional research supported the same result Ha and Baek, (2020), who reported that it is widely assumed that there is a positive association between BMD and BMI and that mechanical loading may account for fat people's higher BMD levels.

Table 5 Shows the BMI distribution.

BMI ranges (kg\m2)	Frequency	Percent	Valid Percent	Cumulative Percent
Less than 18 kg\m2	4	4.0	4.0	4.0
(18-24.9) kg\m2	27	27.0	27.0	27.0
(25-29.9) kg\m2	34	34.0	34.0	34.0
(30-34.9) kg\m2	26	26.0	26.0	26.0
More than 35 kg\m2	9	9.0	9.0	9.0
Total	100	100.0	100.0	100.0
Average mean = 27.73 stdv.5.58				

Table 6 supports the results by demonstrating an apparent correlation between lumber area, neck of femur, and TSH with p-value (.000), as well as the neck of the femur with age and BMI at p values (.004) and (.001). Also, age correlates with BMI and Vitamin D with p-values (.051) and (.053), respectively. That means there was a strong relationship between osteoporosis levels in the lumber area, neck of the femur, TSH, BMI, and vitamin D.

Table 6 Shows correlations between patients' variables.

Correlations		Age	Vitamin D	BMI	TSH	Lumbers	Hip joint
Age	Pearson Correlation	1	.194	.196	.084	.083	.287**
	Sig. (2-tailed)	-	.053	.051	.408	.410	.004
	N	100	100	100	100	100	100
Vitamin D	Pearson Correlation	.194	1	-.043-	.085	-.027-	.074
	Sig. (2-tailed)	.053	-	.668	.400	.793	.463
	N	100	100	100	100	100	100
BMI	Pearson Correlation	.196	-.043-	1	.094	-.137-	-.322-**
	Sig. (2-tailed)	.051	.668	-	.351	.173	.001
	N	100	100	100	100	100	100
TSH	Pearson Correlation	.084	.085	.094	1	.264**	.047
	Sig. (2-tailed)	.408	.400	.351	-	.008	.641
	N	100	100	100	100	100	100
Lumbers	Pearson Correlation	.083	-.027-	-.137-	.264**	1	.385**

	Sig. (2-tailed)	.410	.793	.173	.008	-	.000
	N	100	100	100	100	100	100
Hip joint	Pearson Correlation	.287**	.074	-.322-**	.047	.385**	1
	Sig. (2-tailed)	.004	.463	.001	.641	.000	-
	N	100	100	100	100	100	100
**. Correlation is significant at the 0.01 level (2-tailed).							

4. CONCLUSION

The study supported the DEXA, which plays an essential role in diagnosing osteoporosis and its levels clearly through detecting T-score in lumber and femur neck. It is considered a practical and straightforward modality to determine osteoporosis, where the T-score considered (-2.5) as osteoporosis, and there are two classifications matched with WHO organization according to T-score value, which classified mild osteoporosis (-2.5 to -2.9) and severe osteoporosis (-3 to -4), and women are more affected with osteoporosis than men.

The study additionally showed that osteoporosis is one of the most common diseases that can affect older adults, older people more than young adult people. Lumber vertebrae were the most commonly affected region of osteoporosis than the neck of the femur if not treated, controlled, or managed lifestyle. Furthermore, the study indicated a clear association between risk factors such as vitamin D insufficiency, high TSH level (Hypothyroidism), and osteoporosis. In addition, a greater BMI plays a role in osteoporosis; however, other risk factors such as lifestyle (healthy food, exercise, fat deposits, etc.) can play a role.

Recommendations

Encourage all populations, with particular emphasis on middle adults and the elderly, to live healthy lifestyles such as sports, diet, and nutritious foods to reduce the suffering of osteoporosis and its complications and instill children's proper habits to prevent osteoporosis, which has been described as a silent dangerous disease which is not detected early. Use the T score parameter of DEXA scans to identify the severity of osteoporosis, focusing on the lumbar spine area, and instruct Saudis of all ages about the importance of early prevention.

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Author' contributions

The sole author did all the design of the study and interpretation of the data

Ethical approval

Ethical approval was obtained from King Abdullah Bin Abdulaziz University Hospital KAAUH (Ethical approval number: IRB23-0094E)(HA-01-R-104).

Informed consent

Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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